Technology, and Transformation

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Transformation in the Department of Defense

Definition of Transformation

"*The Evolution and Deployment of Combat Capabilities That Provide Revolutionary or Asymmetric Advantages to Our Forces*"

- QDR (Sep 30, 2001)

QDR Critical Capabilities

- Protect Bases of Operations
- Conduct Information Operations
- Project and Sustain US Forces
- Deny Enemy Sanctuary
- Conduct Space Operations
- Leverage Information Technologies

Protecting Bases of Operations

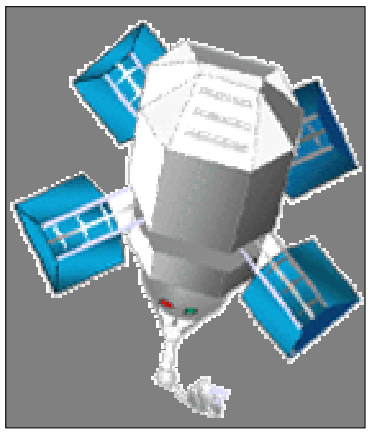
- *Combating Terrorism*
- *Chemical/Biological Defense*
- *Missile Defense*
- *Consequence Management*

Project and Sustain US Forces

- ***Anti-Access Capabilities***

Conduct Information Operations

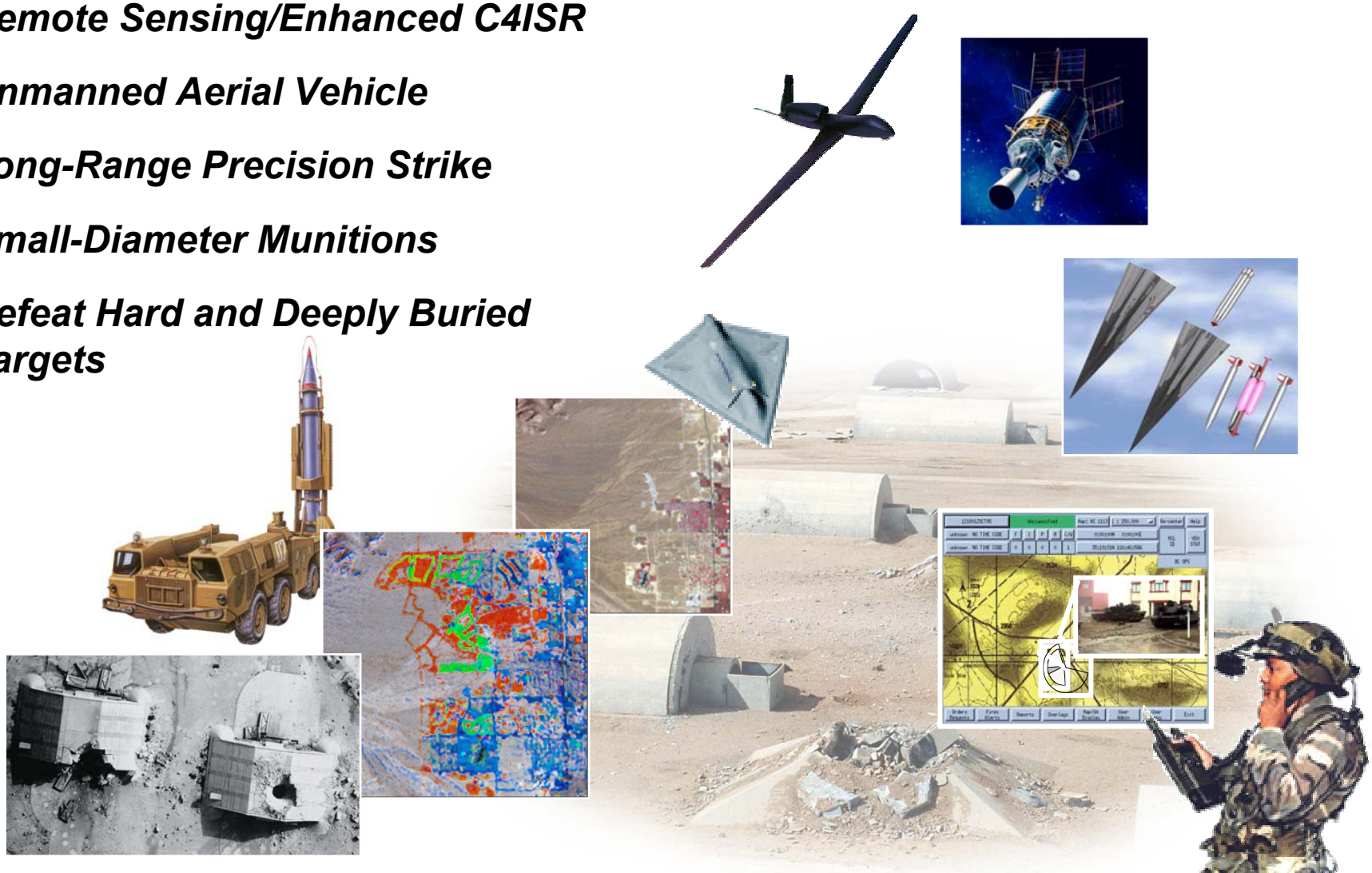
- ***Defensive IO and Information Assurance***
- ***Offensive IO***



Deny Enemy Sanctuary

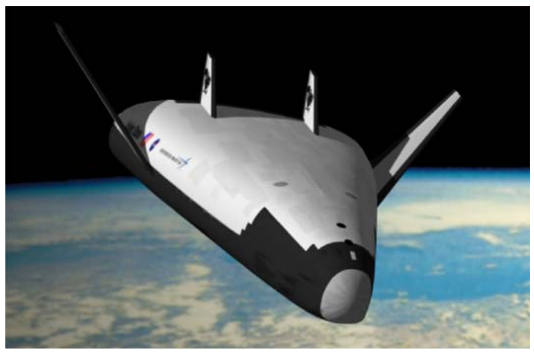
Persistent Surveillance, Tracking and Rapid Engagement with Precision Strike

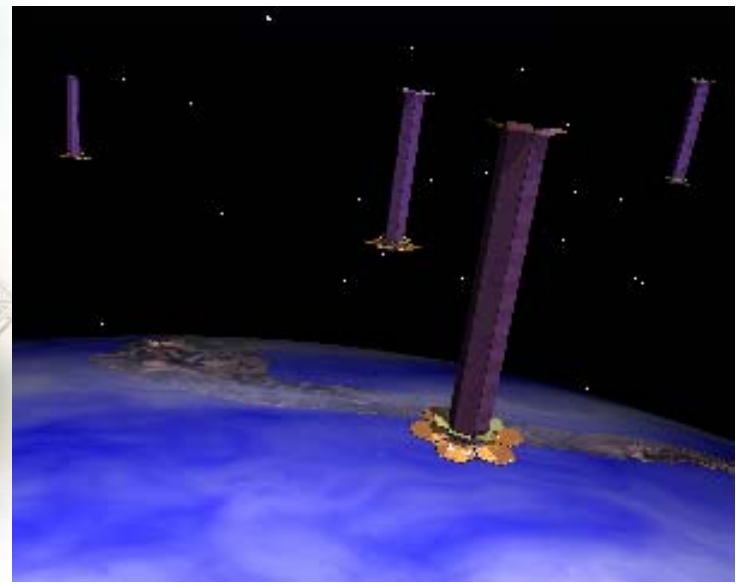
- ***Remote Sensing/Enhanced C4ISR***
- ***Unmanned Aerial Vehicle***
- ***Long-Range Precision Strike***
- ***Small-Diameter Munitions***
- ***Defeat Hard and Deeply Buried Targets***



Conduct Space Operations

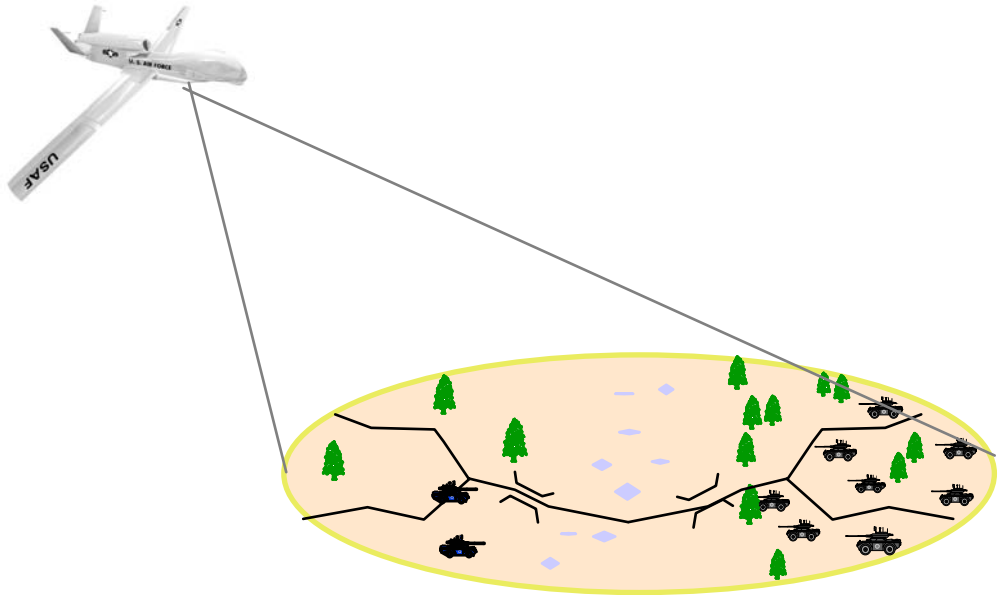
- ***Ensure Access to Space***
- ***Protect Space Assets***
- ***Space Surveillance***
- ***Control Space***
- ***Sub-Orbital Space Vehicle***

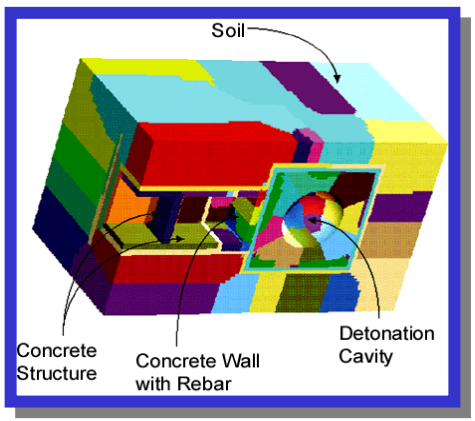


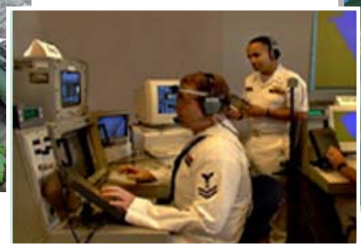


Leverage Information Technologies

- ***High-capacity Interoperable Communications***
- ***Survivable, Improved, Tactical and Strategic Communications***
- ***End-to-end C4ISR***

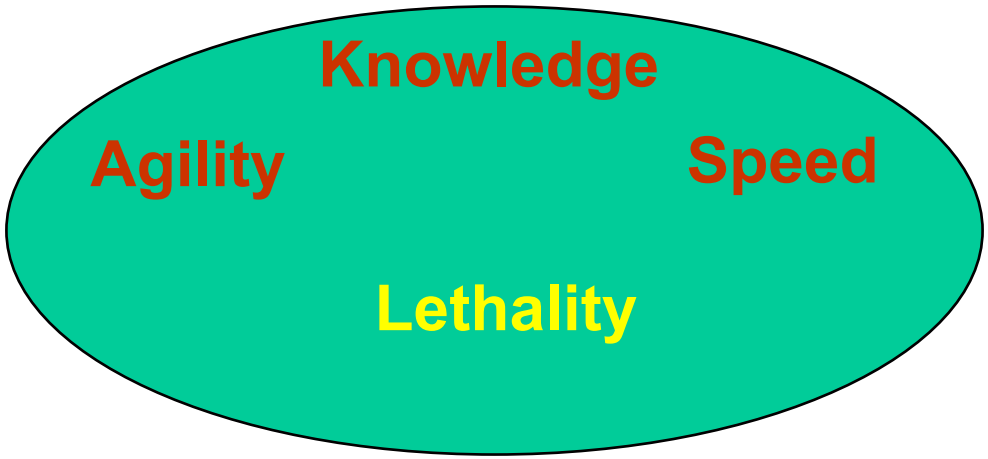






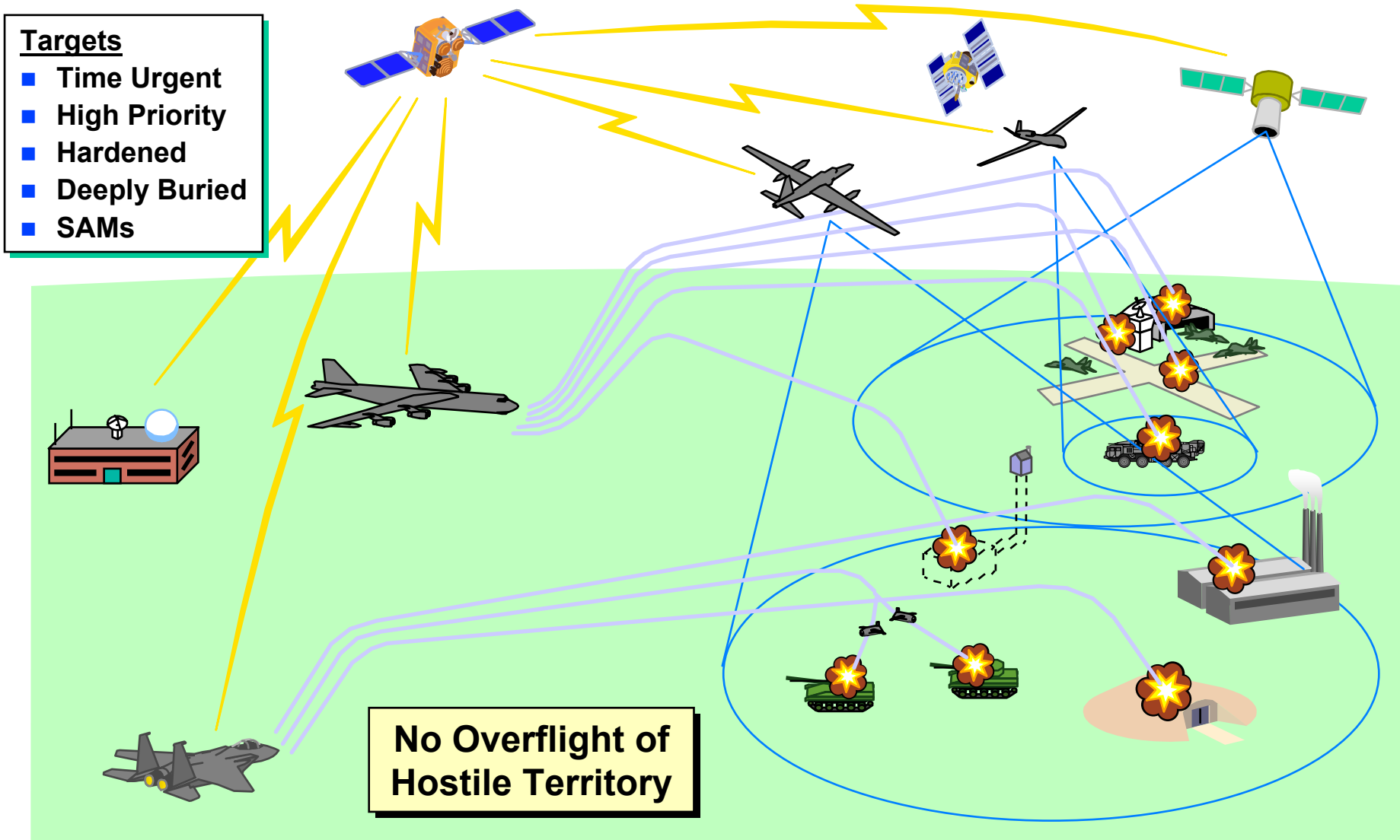
Technology and Transformation

- **Transformation Attributes**

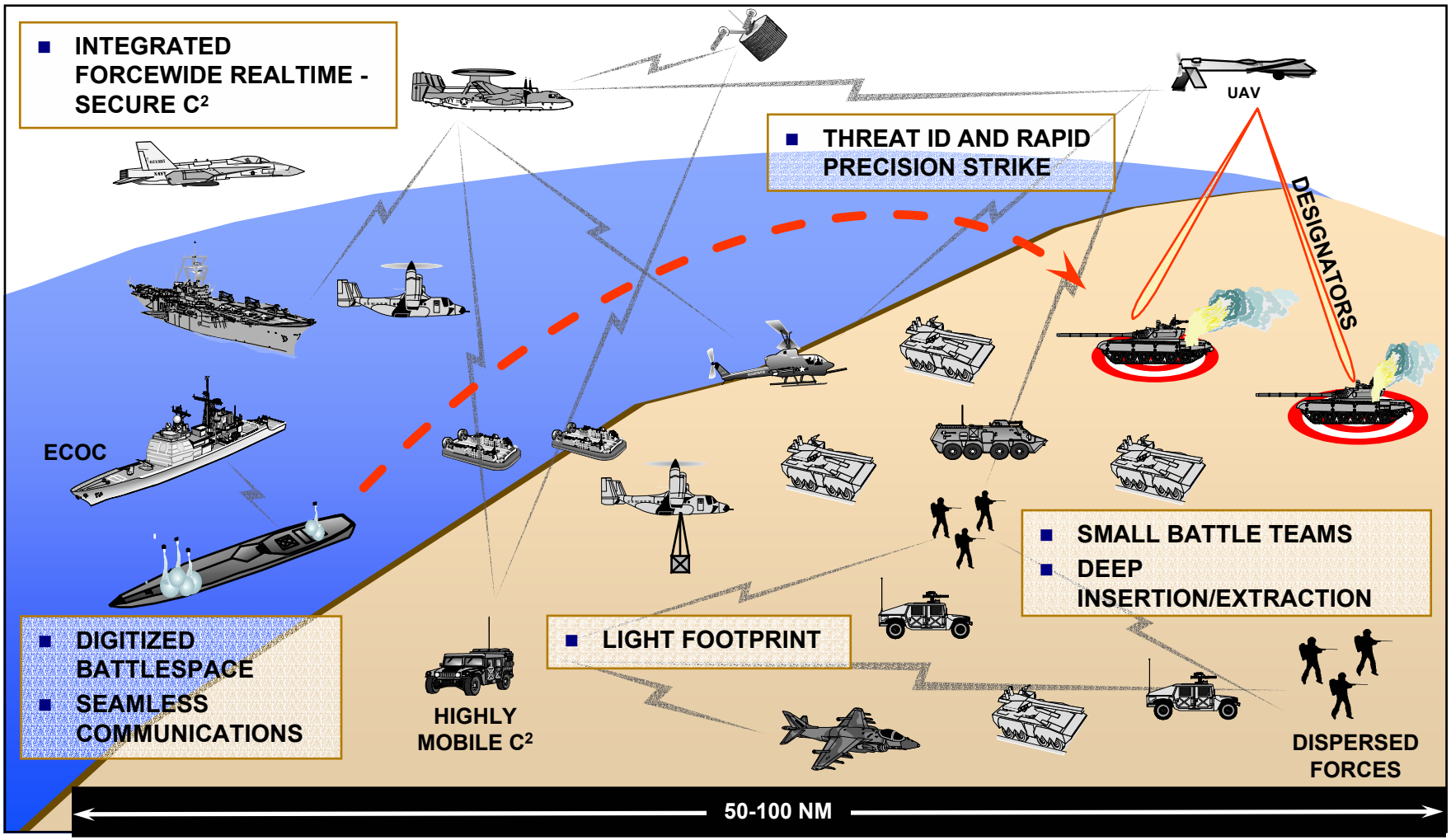


- **Transformation Technology Initiatives**
  - **National Aerospace Initiative**
  - **Surveillance and Knowledge Systems**
  - **Energy and Power Technologies**

Operational Concept



21st Century Littoral Combat



Hard Problem

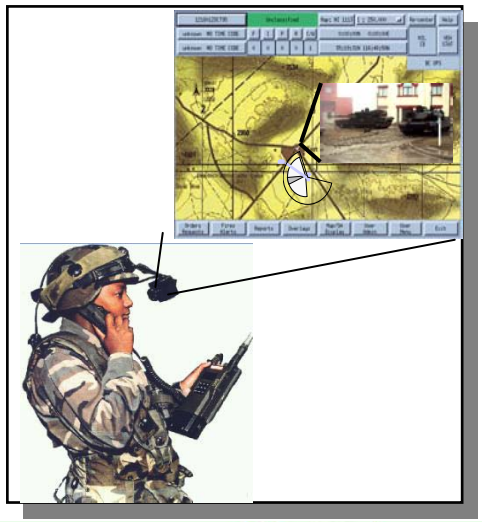
Network Centric Warfare

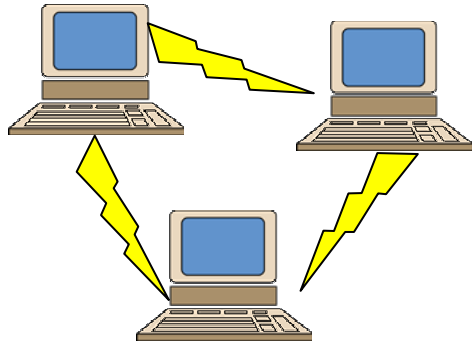
- ***Develop robust M&S connectivity and* interoperability**
- ***Provide information assurance***
- ***Improve decision support***
- ***Improve training***
- ***Expand mission rehearsal capabilities***

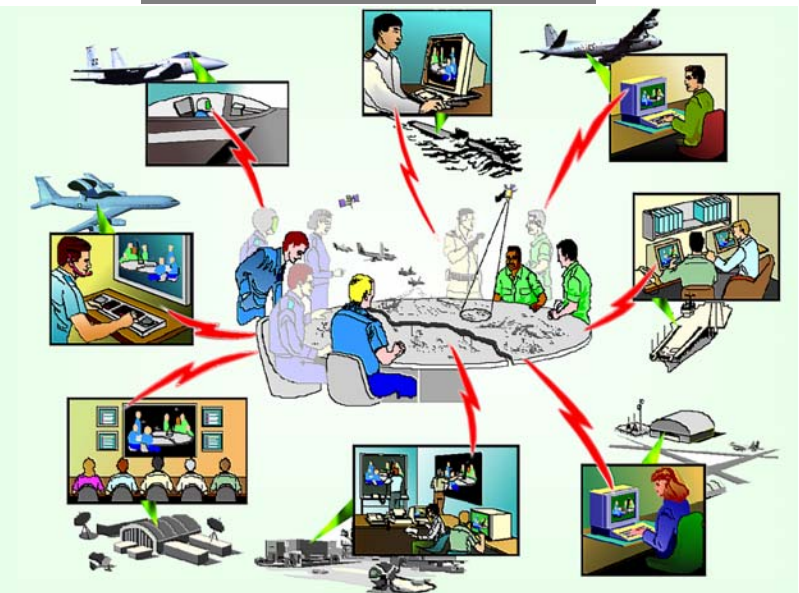
Software Intensive Systems

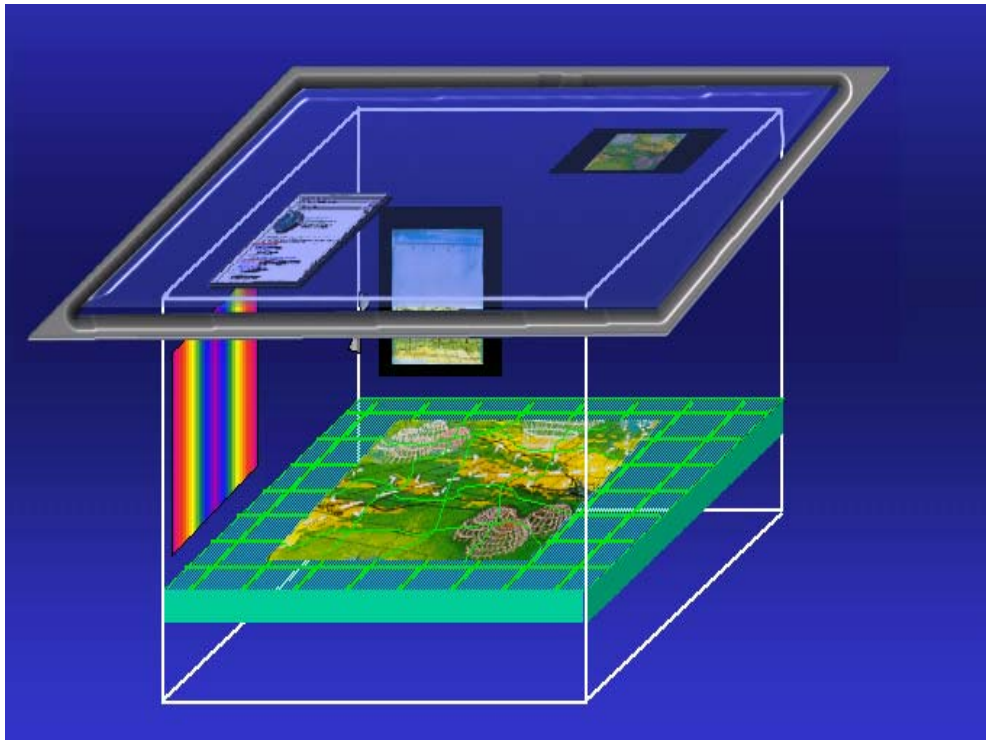
Provides increased combat power by networking sensors, decision makers, and mission executors, to achieve shared awareness, self-synchronization, and improved operations.

Advanced Reconnaissance & Knowledge Architecture



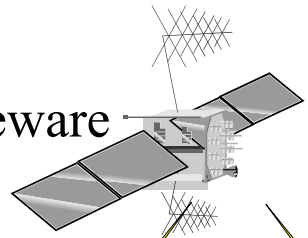




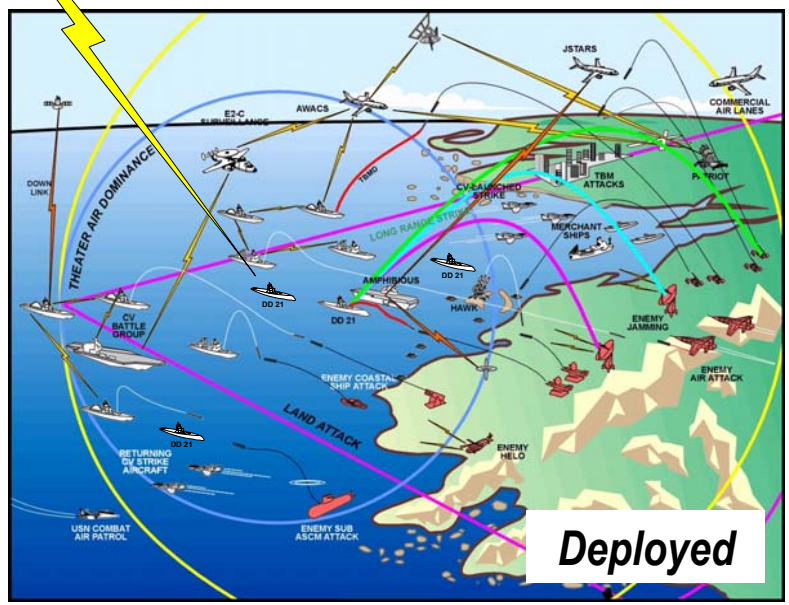


Engineering Challenges
Training

- Embedded trainers
- Intelligent interactive courseware
- Learning resource centers



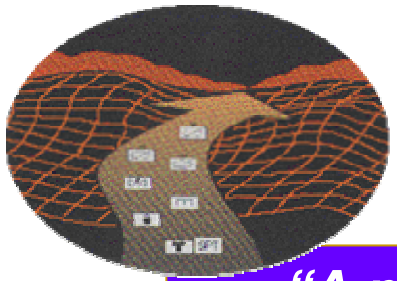
- Distance learning
- Video teletraining
- Distributed / joint simulation



Training anywhere, anytime, on demand

Modeling and Simulation

The Transformation Process - Modeling and Simulation is a Key Enabler

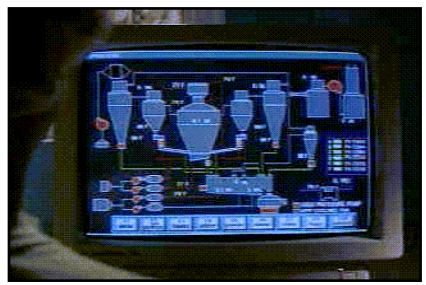


"A new generation of models and simulations will be needed to support distributed training; robust and continuous experimentation; and operational planning, execution, and assessment tools." – Transformation Study Report, Executive Summary, 27 April 2001.

Four Functional Areas for M&S

Experimentation

Training



Analysis

Acquisition

Terminology

M&S Defined

Model: "A physical, mathematical or otherwise logical representation of a system, entity, phenomenon, or process."

Simulation: "A method for implementing a model over time....."

DoD M&S Glossary, Jan 1998

Simulation Domains

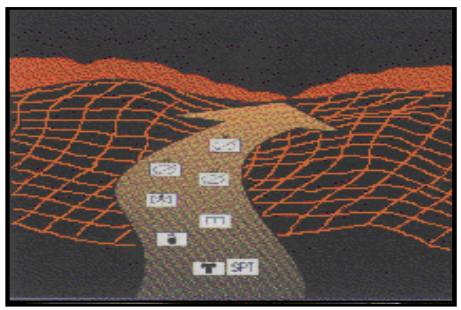
Live

Virtual

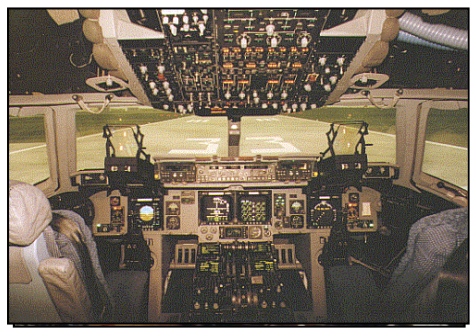
Constructive

Functional Areas

Acquisition

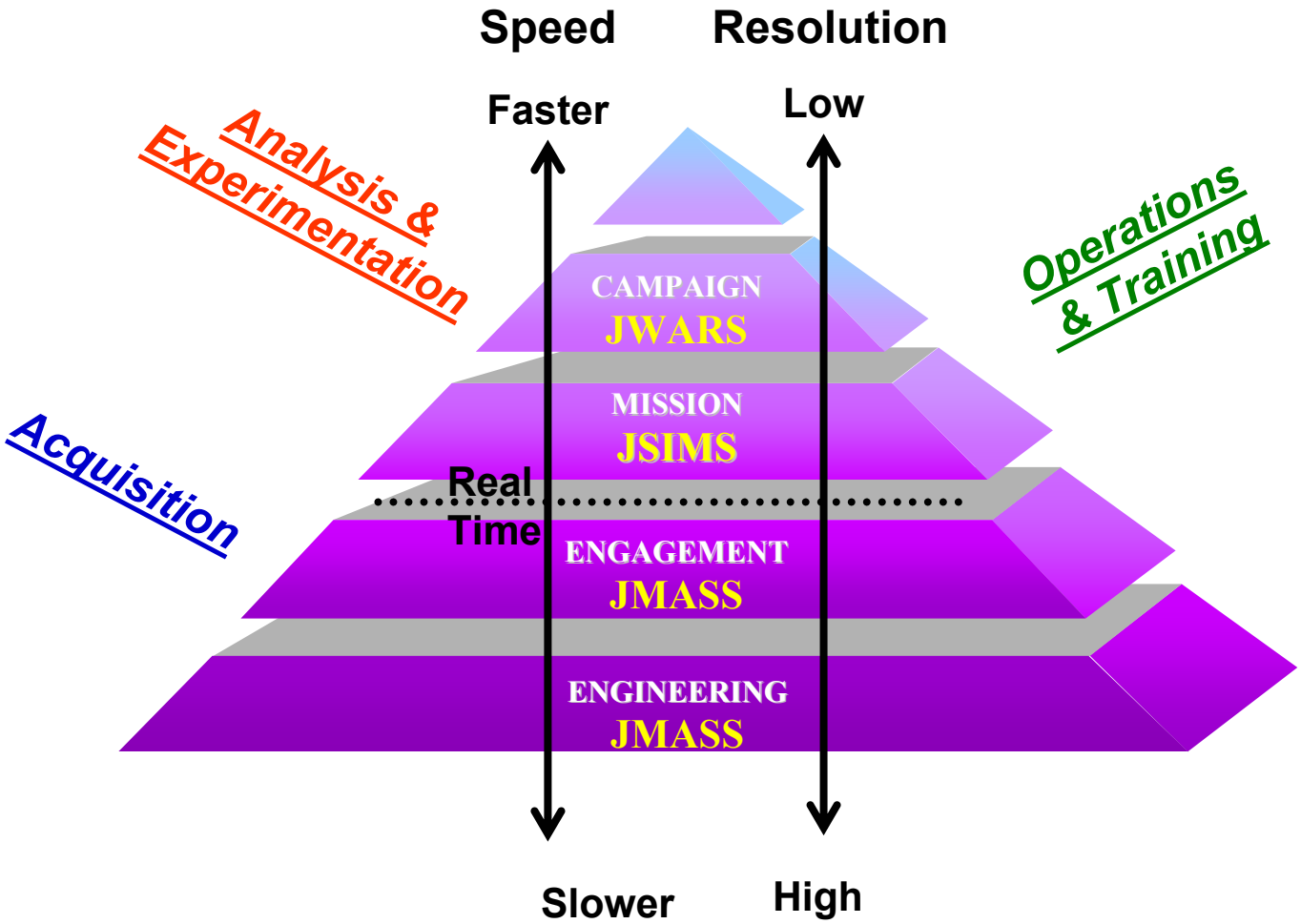


Experimentation & Analysis



Training & Operations

Simulation Programs at each Level



Three Major DoD M&S Functional Area Programs which will incorporate the next generation of simulations and simulation technologies

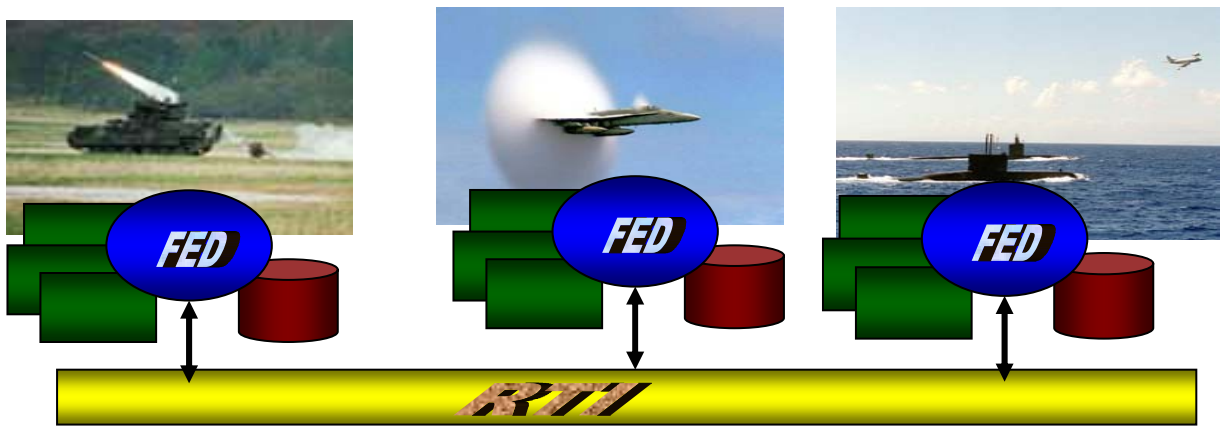
Simulation Environment

- Standards Based Infrastructure
  - Capable of linking new, legacy systems
- Authoritative Data
  - Shared environments with reusable pieces
- New Design Structures
  - Common, reusable servers, composable models
- Metrics and Evaluations
  - VV&A, error tracking

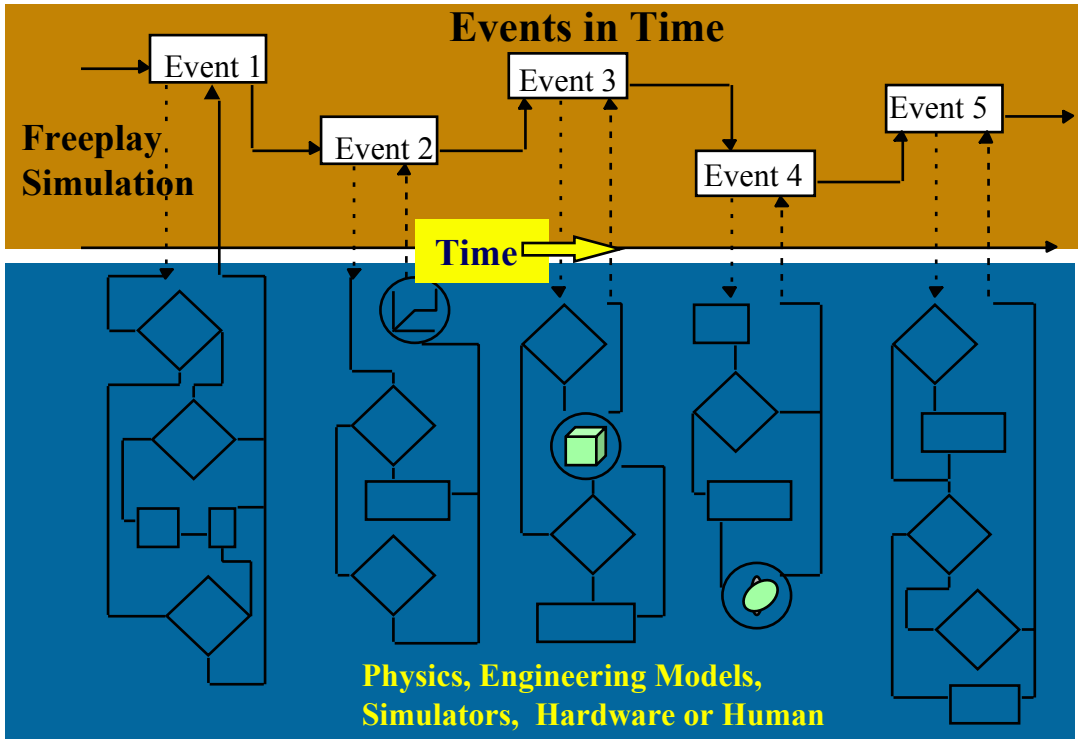
Environment:

Data

Model



What Is Distributed Simulation?



KEY FEATURES

- Independent models -- each built and controlled by expert in that field
- Models execute separately -- implies multiple processors not geographic separation
- Distribute geographically only when hardware or people in the loop make it reasonable
- Common protocols for exchange of information/data

ADVANTAGES

- Authoritative models from experts
- Design base upon which to develop additional models
- Investment can go to solving problems of resolution, aggregation,verification and faster than real time operation

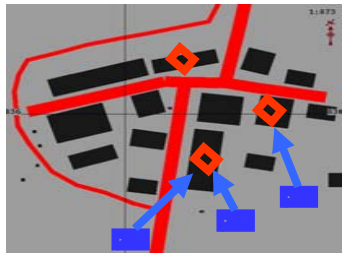
Logic Flow of Distributed Interactive Simulations

where independently executing models
are fed by
and send critical information
to time driven events. (IEEE definition)

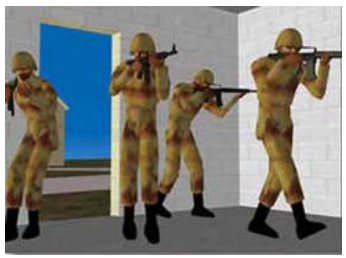
Distributed Simulations

Live

Constructive



Around Town



Virtual

Live

Around the World

Virtual

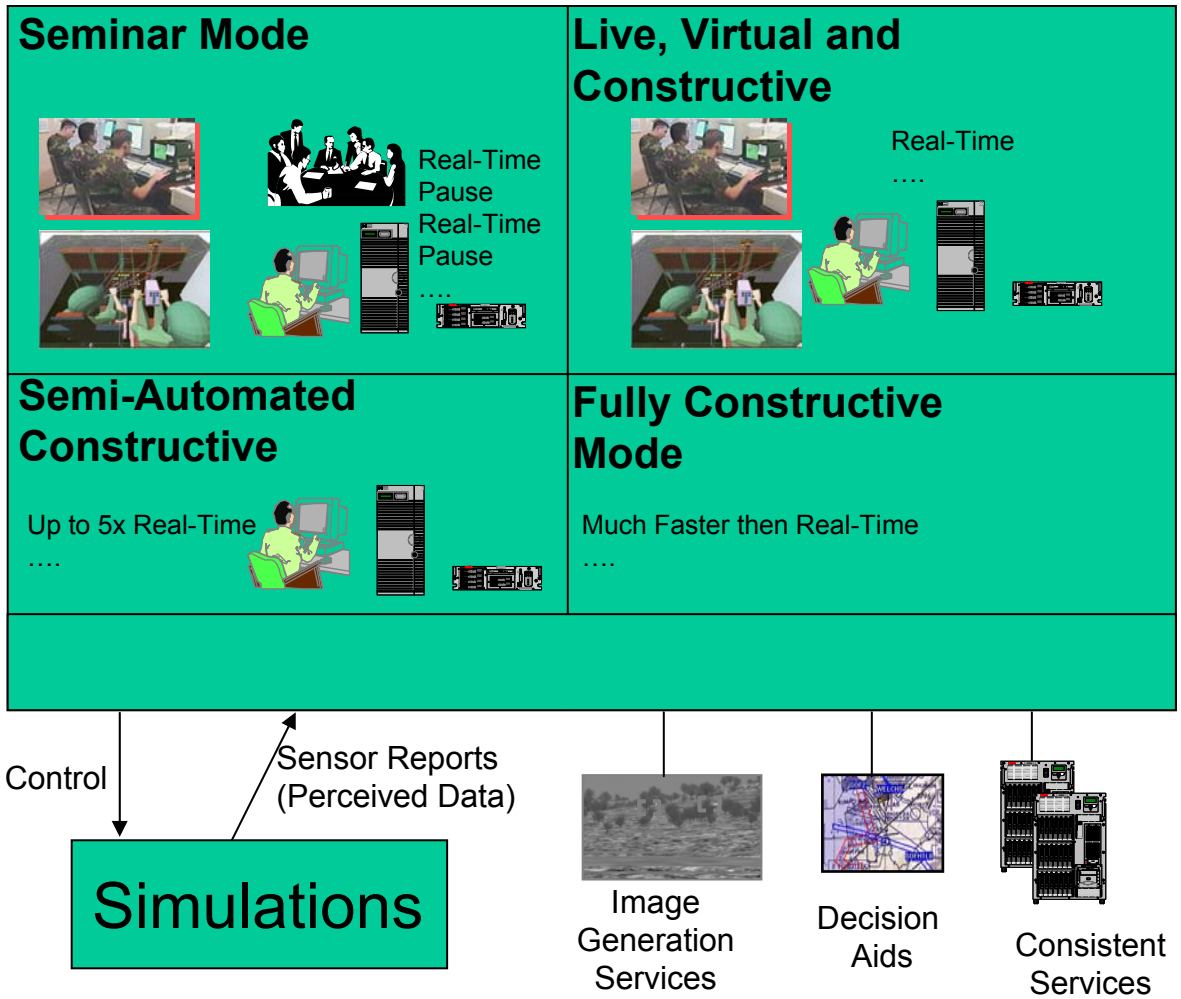
Constructive

Distributed Simulation. Interoperable simulations, sharing information through state-of-the-art communications systems

A Common Vision Representation

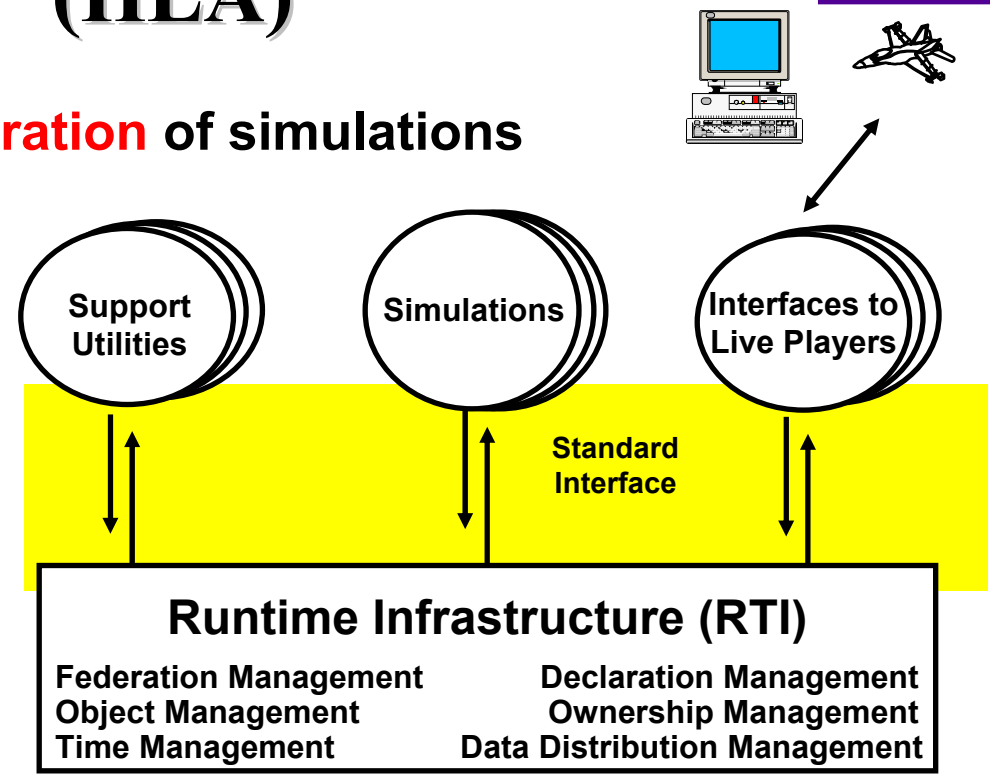
- Supporting multiple functional areas
- Through Live, Virtual, and Constructive Simulation
- With Joint, Interoperable, Re-useable models

Framework Capabilities



High Level Architecture (HLA)

- Architecture calls for a **federation** of simulations
- Architecture specifies
  - **Ten Rules** which define relationships among federation components
  - An **Object Model Template** which specifies the form in which simulation elements are described
  - An **Interface Specification** which describes the way simulations interact during operation



Critical Factors:

Descriptors provided in rules are foundation for reuse
Common descriptors aid common understanding
Common interface aids design and implementation

The HLA is not the RTI;
HLA says there SHALL be an RTI (API conforms to the IFSpec),but it doesn't specify a particular software implementation

M&S Integration in DII/COE

Merging Two Architectures

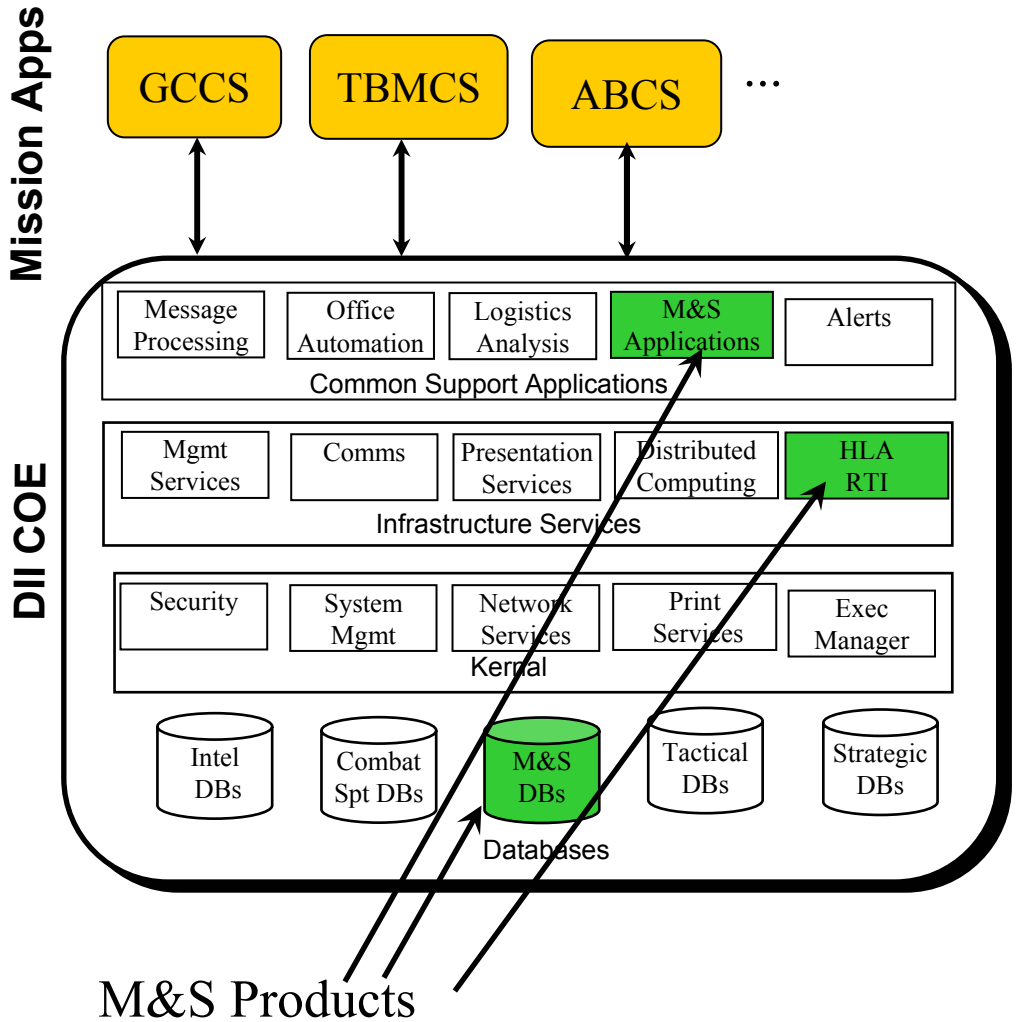
Capability: Train as you Fight
- see simulation results on COP

Problem: M&S too hard to initialize
- Init simulation from planning tools
- Reuse C4I system tools
- Link to live, updated databases

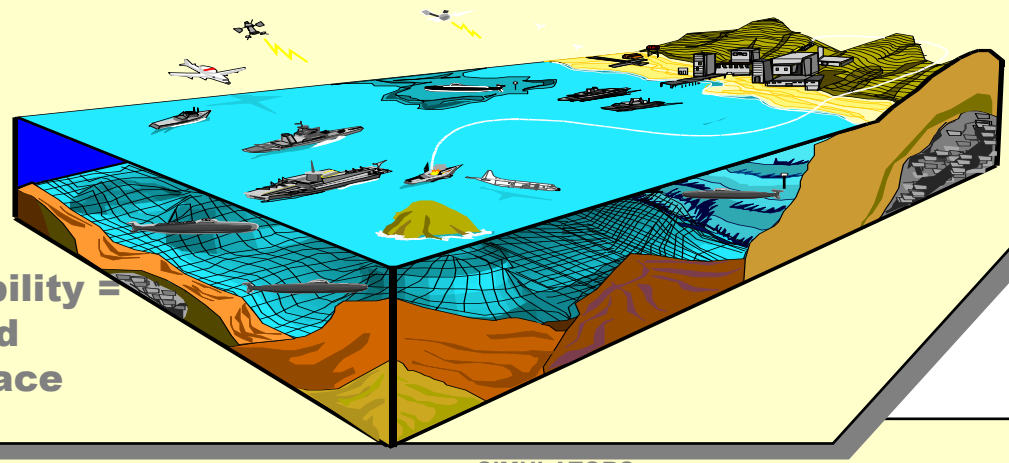
Status:
- Tech Req. Spec (Mar. 01)
- Initial tests (ITEM, NSS) proved very successful
- Building RTI as COE segment to be completed by close of FY02

Partners:

- DISA, AMSO, NAVMSMO, AFAMS, CINCs



“How the Pieces Fit”



Desired Capability = Simulated Mission Space

ENGINEERING MODELS

SIMULATORS

SYSTEM TESTBEDS

BATTLE LABS

C^4I

GLOBAL GRID

DSI / DISN LES GCCS

NATIONAL INFORMATION INFRASTRUCTURE

ACTDS

WARGAMING CENTERS

Comm Connectivity

↖ POLICY & DIRECTIVES
↖ COMMON TECHNICAL FRAMEWORKS
↖ PROTOCOLS & STANDARDS
↖ COMMON REPRESENTATIONS
↖ COMMON SERVICES
↖ CONFORMANCE

Interoperability & Reuse

Assessment

National Defense Domain Evaluation of Current M&S

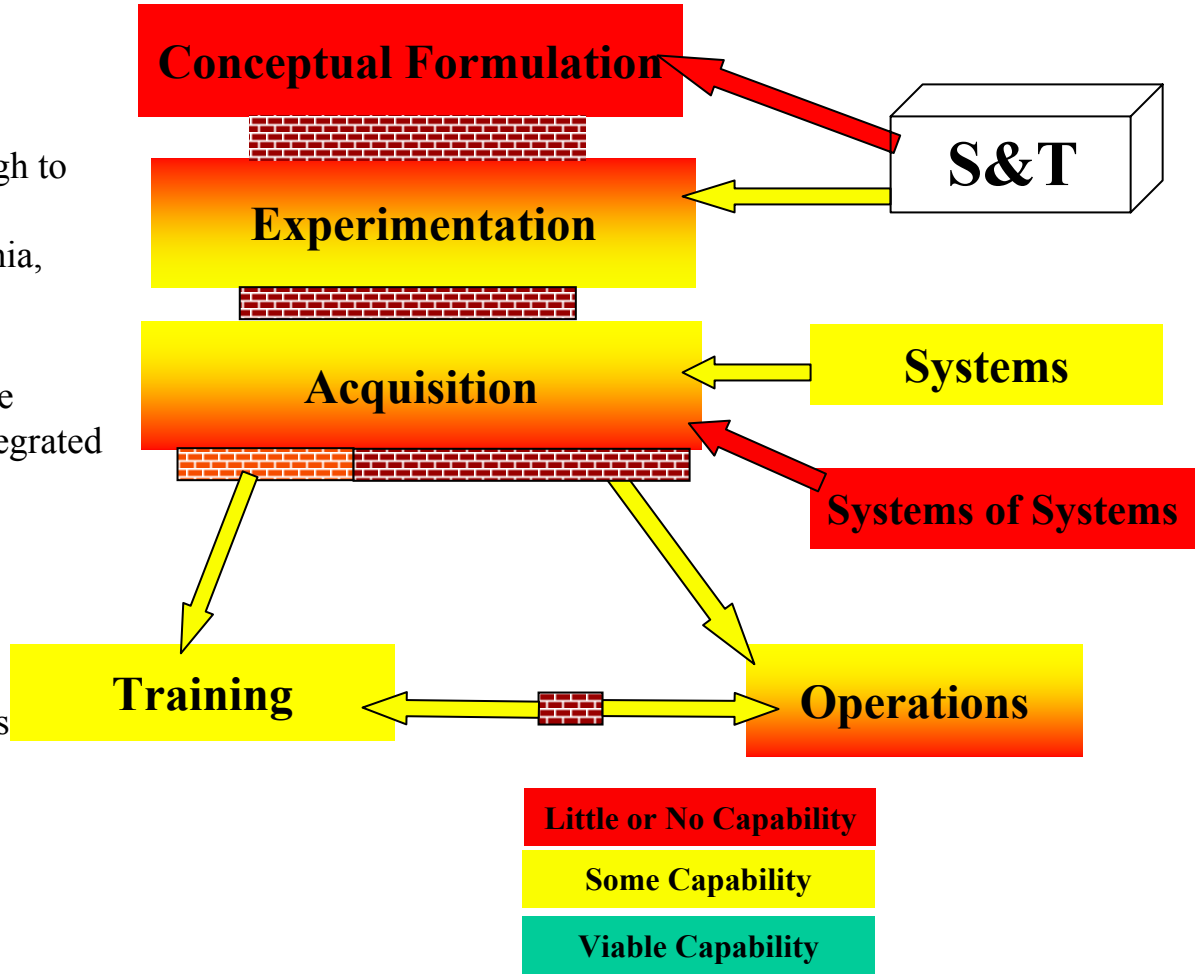
Conceptual Formulation:
- Scope limited to cold war ideas
- Do not have flexible tools good enough to stimulate creative thinking
- Insufficient participation from academia, industry, military, other gov agencies

Experimentation
- Initiated, but not robust and responsive
- "J" efforts need to be truly joint & integrated

Acquisition
- Tools designed only for single system
- Lack metrics, inadequate process for systems of systems

Training
- Service Specific/Stove-piped solutions
- Tools need to be better, shared, joint

Operations
- Need Joint, Collaborative Planning/Rehearsal systems needed
- Insufficient training for new conflict



Communities are separate, no incentive to work across boundaries

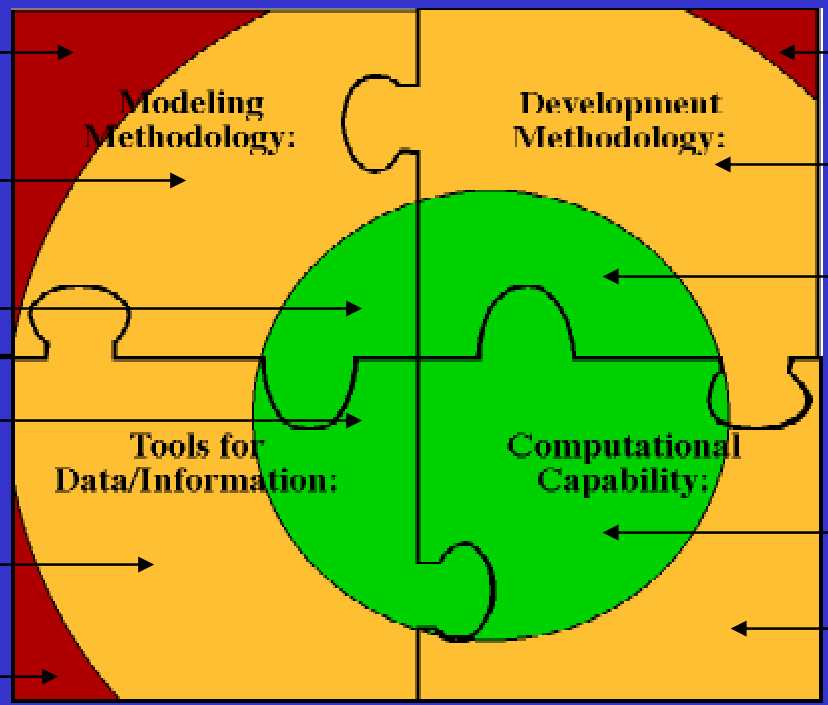
Common Threads:Repositories don't describe models for reuse and classification
M&S is hard to use, inflexible, opaque and underfunded

Aggregate Comparison of User Needs and Technology Projections

Needs fall below conservative projections

Needs range from Just below aggressive, to Just above conservative projections

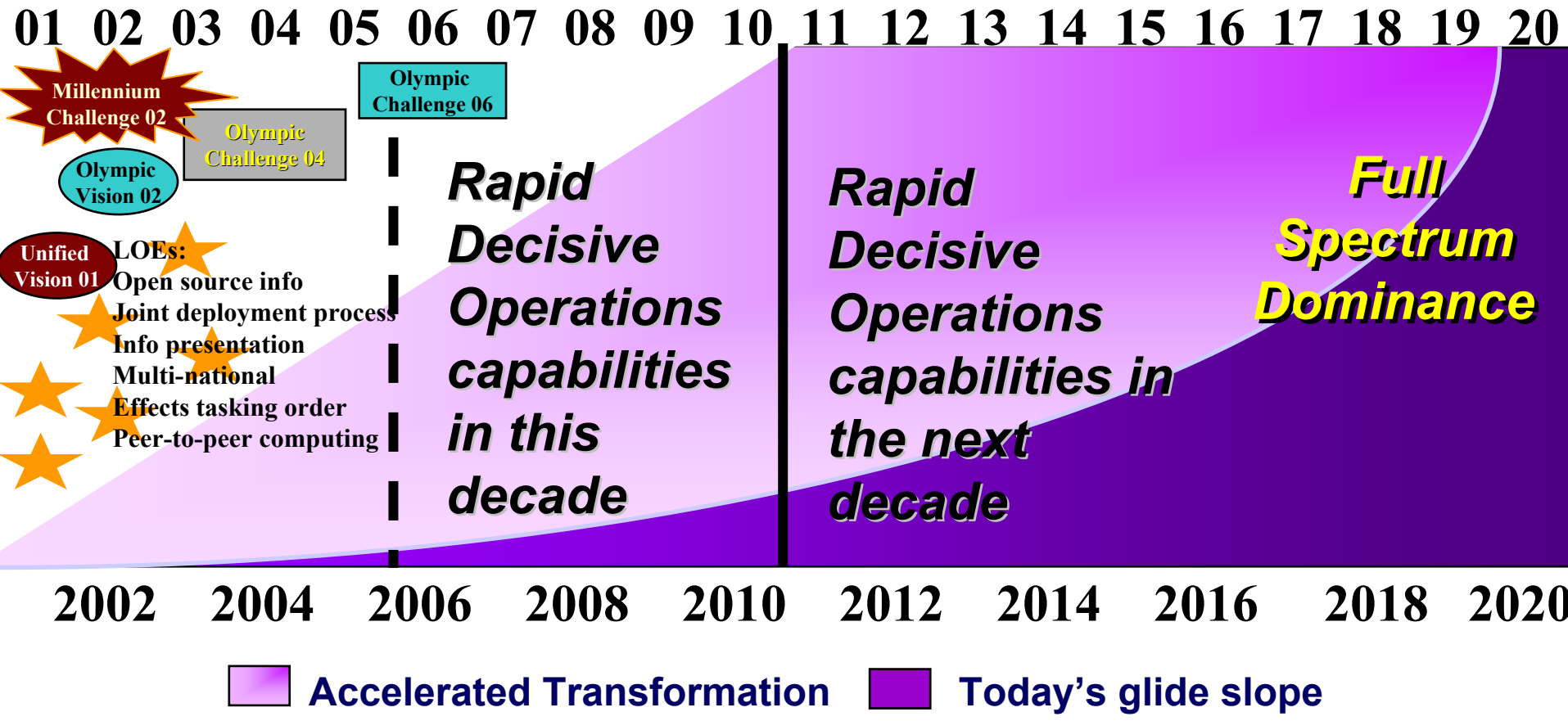
Needs exceed aggressive projections



- Cognitive
- Performance modulators
- CGF
- Decision Support
- System/organizational effects
- Requirements Process
- Physical
- Human/computer interface
- Analysis
- Collaboration
- Acquire/capture
- Storage
- Accessibility
- Ownership/control

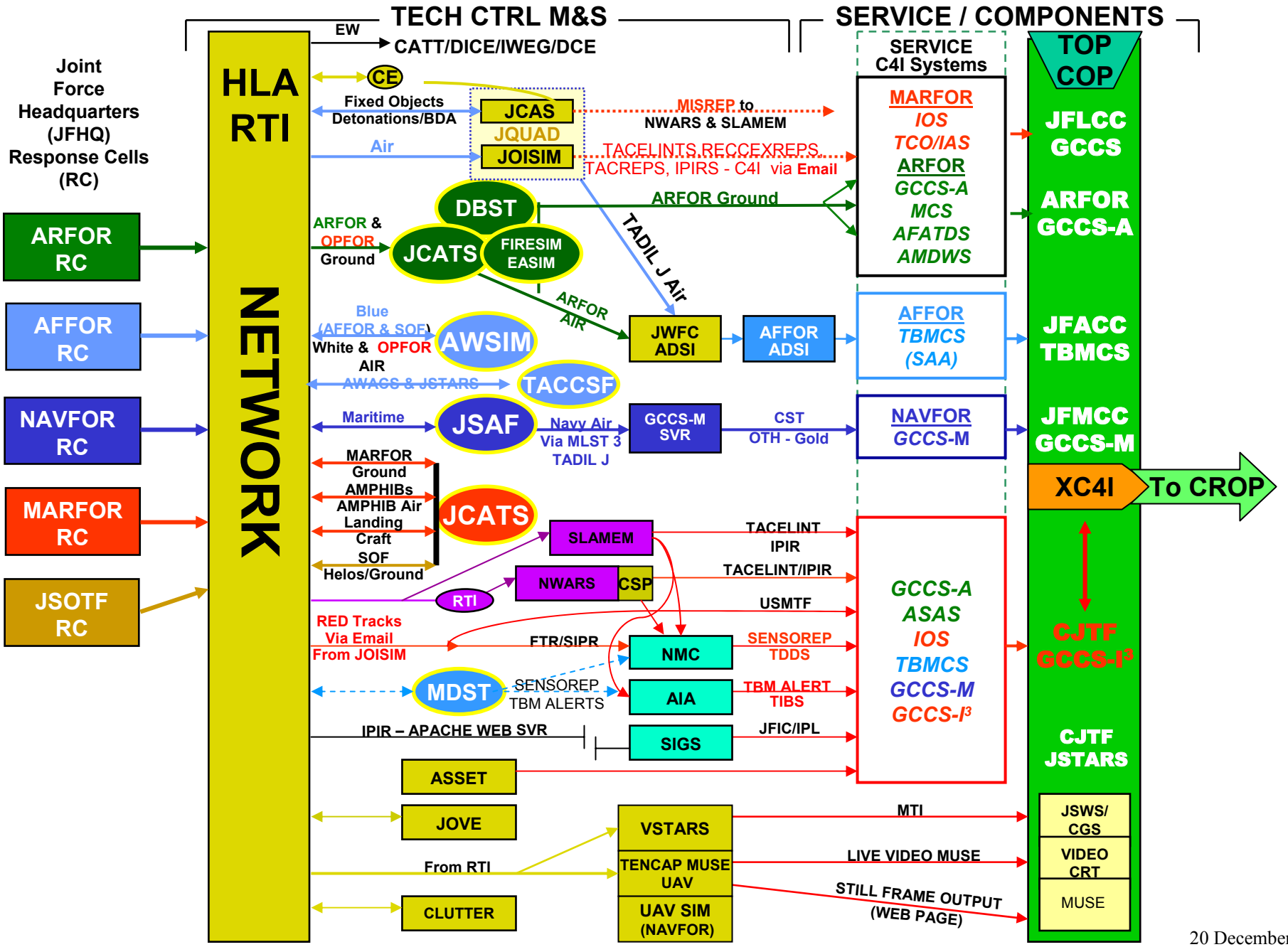
- Scalability
- Composability
- System arch/eng
- Standards
- Sim Frameworks
- Commercial games
- Network Speed
- Distributed computing
- Network setup
- Security

Joint Experimentation



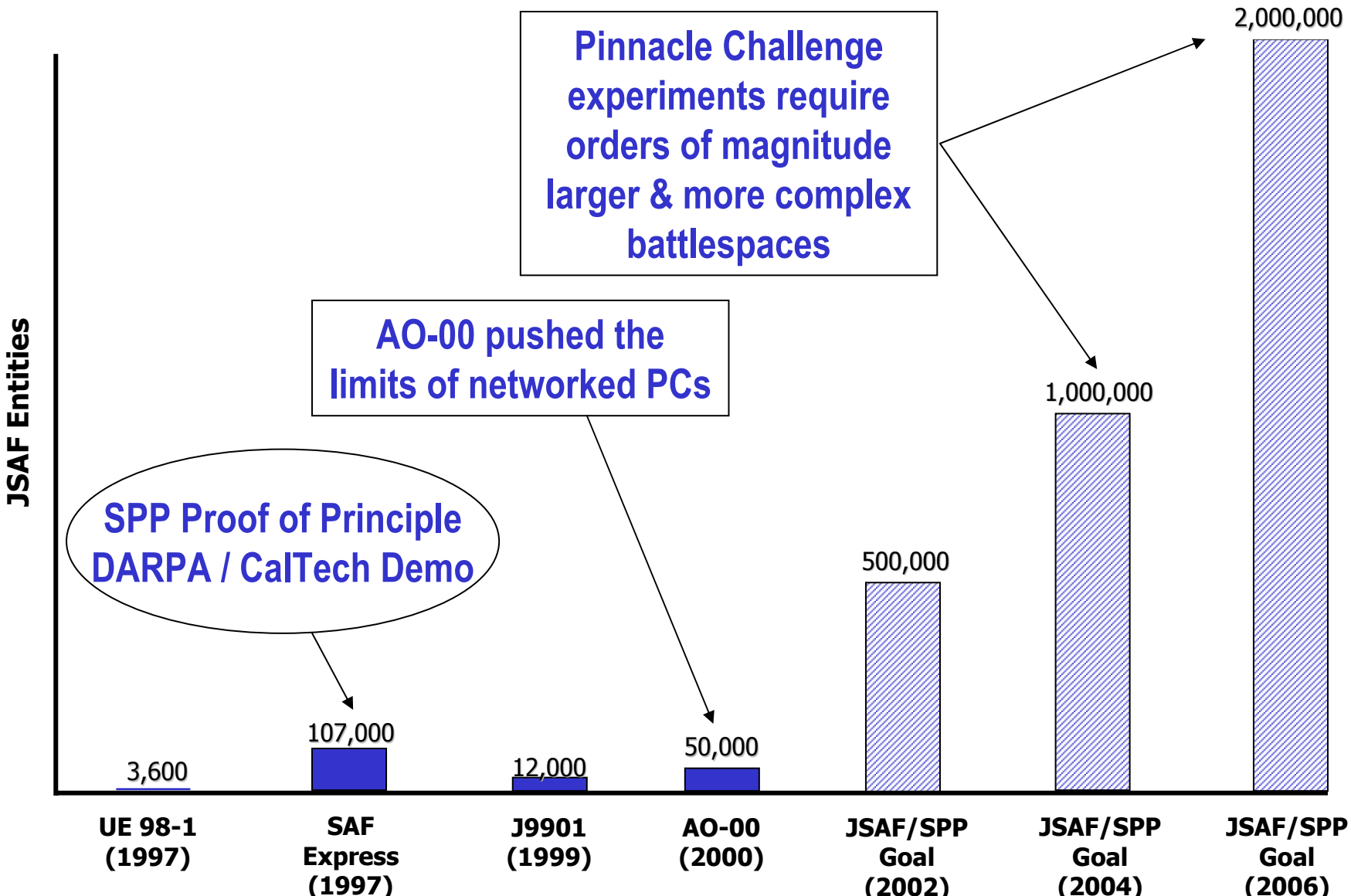
Joint experimentation will provide insight for technology insertion/expansion in Limited Objective Experiments (LOEs) and Olympic Challenge (OC) 04/06. Technologies will likely have reuse in Joint Battlespaces

MC02 M&S/C4I Simulation Data Flow

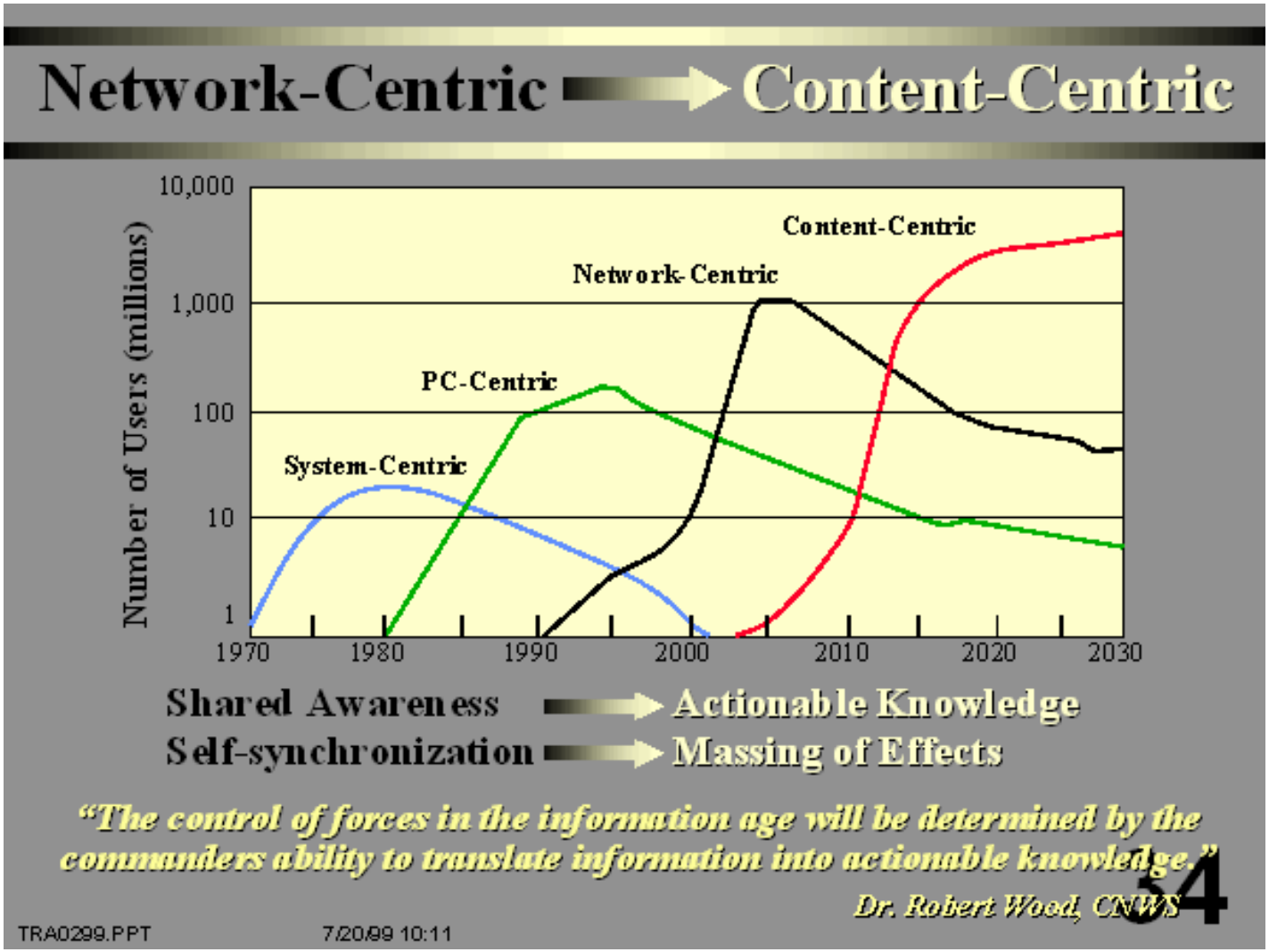


20 December 01

The Scalability Challenge



Evolving Representation of Complexity



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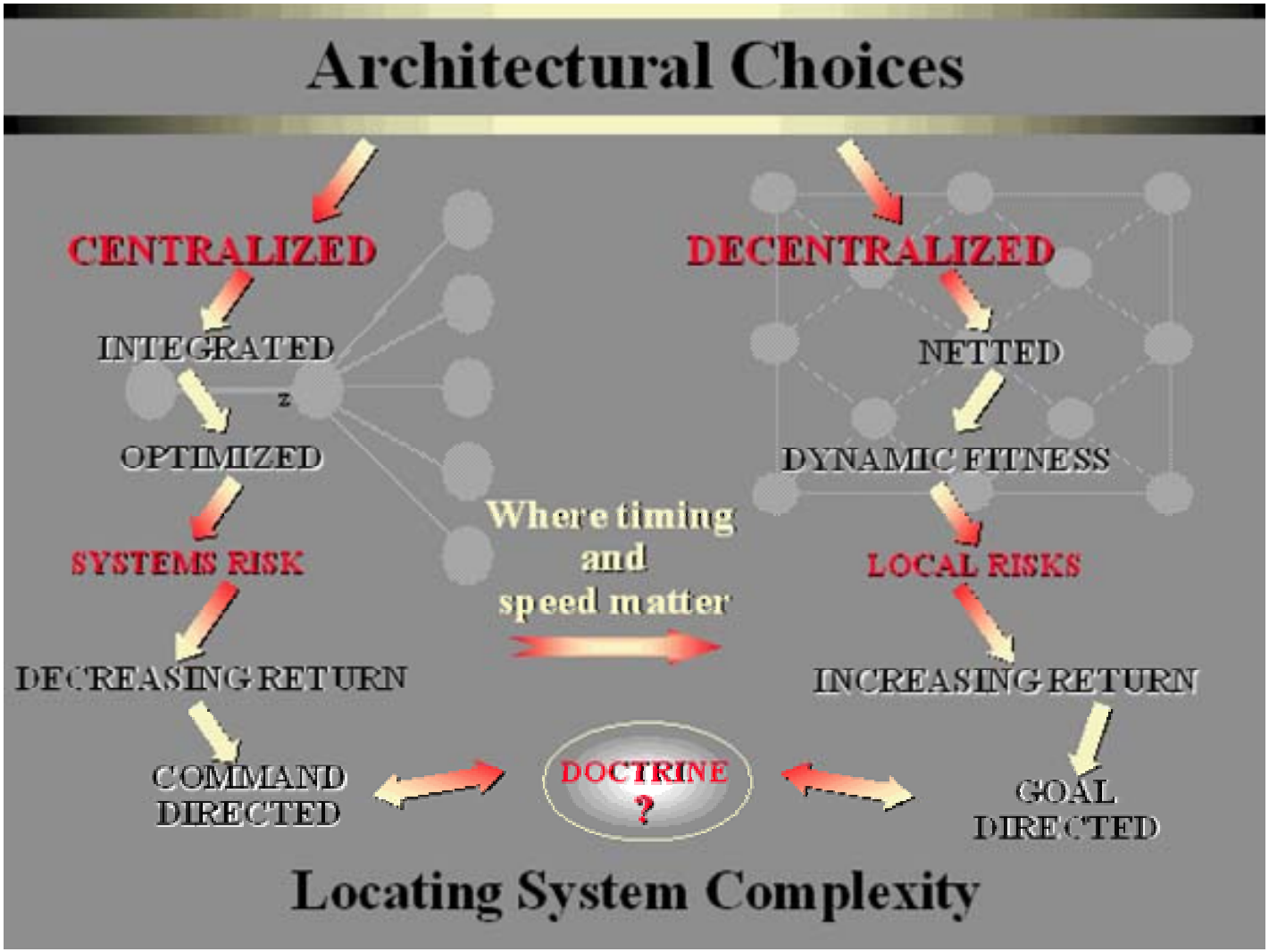


Networking Simulations
Live – Virtual - Constructive

Networking for Distributed Simulation

- The network is a fundamental component of a distributed simulation
- Biggest payoff from distributed simulation requires a wide-area network
  - very rapid composition of models and organizations in response to unexpected challenges
  - significant cost savings from travel avoidance
- However, the network technical requirements for the distributed simulations we can envision far outstrip the capability of today's technology

Multicasting and Distributed Simulation

- Distributed simulation inherently requires many-to-many group communication
- Not broadcast (all-to-all) but communication among groups of simulations that can all “see” the same inputs (many-to-many multicast)
- For a complex simulation, there may be many overlapping groups
  - just the problem of assigning groups and keeping them up-to-date is hard

Issues in Networking for M&S
Critical Factors:

- Latency: how to predict and control it across networks with radically different bandwidths
- Quality of service: do we know how to specify it well enough
- Protocols: currently simulations use UDP and not IP, is this a problem for networks with heterogeneous components and firewalls
- MLS: multi-level security operation, will the political and technical worlds ever converge on solutions
- Sharing networks: managing tactical systems and simulations both of which tend to want to control the network operations

Where Can Networking Research Help?

Networking technology solutions that scale to:

- Thousands of multicast groups with hundreds of join/leaves per second
- Many-to-many multicasting for tens of thousands of simulations
- Mix of reliable and best-effort multicast traffic
- In a shared internet with secure real-time performance

Issue: Modeling Network Performance for Simulation

- Background: simulations use the network for transactions (entity interactions) and moving large databases periodically (such as time varying weather data)
- Issue: how to simulate network performance when simulation traffic is scenario dependent

Situation Think Pieces

Situation 1: No Requirement for Reach Back to CONUS

- How will you manage seamless linkage across different bandwidths
- How will you predict performance
- How how will you transfer the occasional large database

Situation 2: Reachback beyond Line of Sight

- Satellite links between battlegroup and shore
- If you could predict network behavior in a homogeneous networks, what is the effect of adding a low bandwidth link
- How can you manage data flow for large, time-dependent databases

Situation 3: Now Add Cellular Communication for Ground Troops

- Satellite links between battlegroup and shore
- If you could predict network behavior in a homogeneous networks, what is the effect of adding a low bandwidth link
- How can you manage data flow for large, time-dependent databases

Virtual Distributed Worlds

Serious Play is not an Oxymoron
It Is The Essence of Innovation


The Ultimate Precision Weapon
QUESTIONS?

RFC 2502

- Internet Engineering Task Force (IETF) is the standards body for internet protocols
- In 1999 a working group of the IETF studied the “Large Scale Multicast Environment (LSMA)”
  - authors Pullen, Myjak and Bouwens
  - DMSO sponsored participation
- Produced “Limitations of the Internet Protocol Suite for Distributed Simulation in the Large Multicast Environment”
  - summary of technical networking requirements for distributed simulation and similar applications
  - published as informational standards document (“Request for Comments”) RFC 2502
  - very long technology horizon still valid today (and probably for years to come)

RFC 2502 Requirements

On an end-to-end basis among all participating simulations:

- Real-time delivery
  - low loss (random losses, less than 2%)
  - low latency/jitter (less than some specified threshold on the order of a few hundreds milliseconds)
- Thousands of multicast groups
  - hundreds of join/leaves per second
- Many-to-many multicasting for tens of thousands of simulations
- Mix of reliable and best-effort multicast traffic
- Resource reservation for shared networks
- Secure networking in an internetted environment

Why These Requirements?

- Real-time delivery
- Low loss:
  - each simulation must have an accurate picture of the state of all other simulations
- Low latency/jitter:
  - status updates must occur rapidly enough to provide an accurate representation of reality
    - typical threshold 100 ms or 300 ms
    - in some cases, bumping up against the speed of light in wide area networks
  - jitter (variation in latency) must not cause the required updates to arrive late

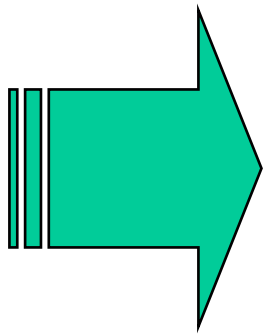
Why These Requirements?

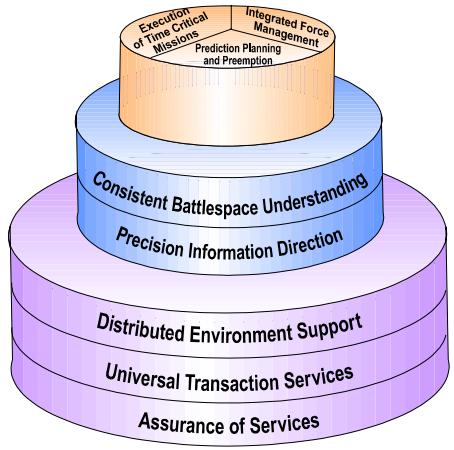
- Thousands of multicast groups with hundreds of join/leaves per second:
  - this is the scale of a large military activity
- Many-to-many multicasting for tens of thousands of simulations
  - inherent requirement of distributed simulation on the scale of large military activities
  - recently IETF multicast development has been focused on one-to-many delivery (easier to do, more common problem - but bad news for DMSO)
- Mix of reliable and best-effort multicast traffic
  - much of the simulation state data is redundant
  - too expensive to send it over and over- we need real-time reliable multicast for this part of the traffic

Why These Requirements?

- Resource reservation for shared networks
  - impractical/inefficient to build a network for each distributed simulation
  - like the rest of the world, defense benefits from internetting its elements
  - IETF Differentiated Services (DiffServ) and MultiProtocol Label Switching (MPLS) show promise for meeting this need
- Secure networking in an internetted environment
  - in this shared network, we must protect sensitive/classified data
  - protocol architecture for this now exists (IP Security)
  - achieving required security is both a technical and an organizational problem

Warfighter's M&S Needs

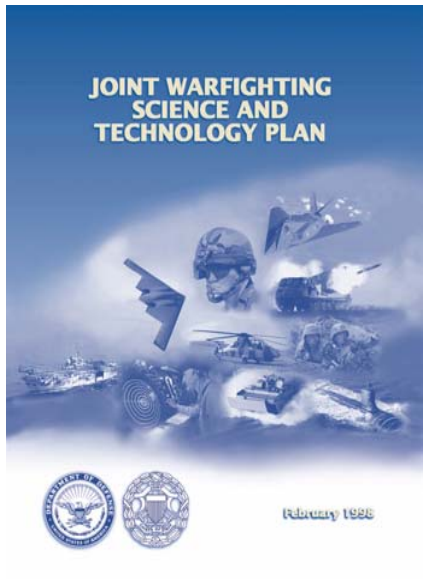




CINC Needs (WARMOND Data Base)

- Link to C4I systems (w/reach-back)
- Faster, less costly database development
- Standardized (reusable) components
- Reduced overhead
- Operational data collection
- Access to terrain for operational areas
- Tools for operational decision-making
- Improved human performance modeling

Warfighter's M&S Capability Needs



Joint Warfighting Capability Objectives (13)

- Information Superiority
- Precision Engagement
- Combat Identification
- Air and Missile Defense
- Military Operations in Urbanized Terrain
- Joint Logistics and Sustainment of Strategic Systems
- Dominant Maneuver
- Electronic Warfare
- Counterproliferation of Weapons of Mass Destruction
- Combating Terrorism
- Protection of Space Assets
- Hard and Deeply Buried Targets
- Warrior Readiness

M&S needs in:

- Analysis
- Acquisition/Modernization
- Training
- Battlespace Visualization
- Mission Planning/Rehearsal
- Environmental, system, & human representations